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THE PROMINENT POLAR AURORA OF 11 FEBRUARY 1958

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THE PROMINENT POLAR AURORA OF 11 FEBRUARY 1958

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by L. S. Yevlashin

The type A - red color aurorae constitute a relatively rare phenomenon in the polar aurora zone (Murmansk station), even in the year of solar activity maximum, by comparison with their observations at lower latitudes or near the polar zone itself [1]. It is generally well known that such aurorae are due to enhancement of red oxygen lines λ 6300 - 6364 Å relative to the green line. The increase in intensity of the lines 1 PG N_2 in the type A red aurorae does not correspond to reality. In spectra obtained with the aid of a C-180-S camera with a ten-minute exposure, the first positive nitrogen system is never revealed in such type of glows.

To the contrary, correlating with the green oxygen line λ 5577 Å, the lines 1 NG N_2^+ may have a significant intensity. In the case when the red glow is observed in twilight, i.e. when it is in the sunlit region, an anomalous development of lines 1 NG N_2^+ rotational structure takes place, which is noticeable even in the C-180-S spectra with a 50 Å resolution. When the ratio $I\,\lambda\, 6300\,Å / I\,\lambda\, 5577\,Å \geqslant 2$, hydrogen emission is never observed in the red glows [3].

Among red glows of the A-type the aurora of 11 Feb. 1958, grandioze in its scale and brightness, and observed in the greater part of our planet, occupies a particular spot. Although all basic laws inherent to type-A red glows are here fully preserved, it deserves a special attention

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attention, for no similar phenomena were observed in the Murmansk region since the beginning of IGY till the present time.

There are published works devoted to the 11 February 1958 aurora. Thus, for example, numerous spectrographic and photometric investigations of various phases of the aurora carried out at low latitudes, have been described in references [4 – 8]. A series of interesting papers were also devoted to analysis of that aurora according to observations made near the zone of polar aurorae [9 – 11] However the observation time encompasses in this case the fundamental and the final stage of the aurora.

In Murmansk, per contra, it was possible to register only the initial phase of that aurora (01 00 to 05 00 hours GMT on 11 Feb. 1958), for the sunrise prevented its further observation. The current work is precisely devoted to the analysis of that material.

60 spectra with 2, 10 and 12 minute exposures were obtained during the night from 10 to 11 February with the aid of a C-180-S spectral camera with a 50 Å resolution. At the beginning green glow of medium intensity was noted, but its photographing was at times prevented by blizzards. On account of that, an insignificant part of the slit resulted plugged by a dense snow crust, and the southern parcel of the sky (0 – 45°) thus failed to register in all the spectra.

Only 37 spectra had direct bearing on the investigated aurora. They were obtained between 23 33 and 04 57 hours GMT. The C-180 and CZ photographic cameras began their operation only sometime after 02 08 hours, thus unfortunately the whole sequence of aurora development could not be followed with their help. The processing of the available cameras' C-180 and CZ material attests to the fact that the intensity of all sky glow was exceedingly high and that separate forms of the aurora went unnoticed even on clichés with a 5-second exposure.

The results of film photometry are brought out in Fig. 1 next page. The glow intensity of the 11 Feb. 1958 aurora is here juxtaposed with the brightness of the pure twilight sky at zenith during the morning of 16 – 17 February 1958).

As may be seen, the glow intensity exceeds by 2 to 3 times the brightness of the pure twilight sky, even during the less bright phase of aurora development, when the Sun's zenithal angle is 99°, i.e. when all the atmosphere about 80 km is illuminated.

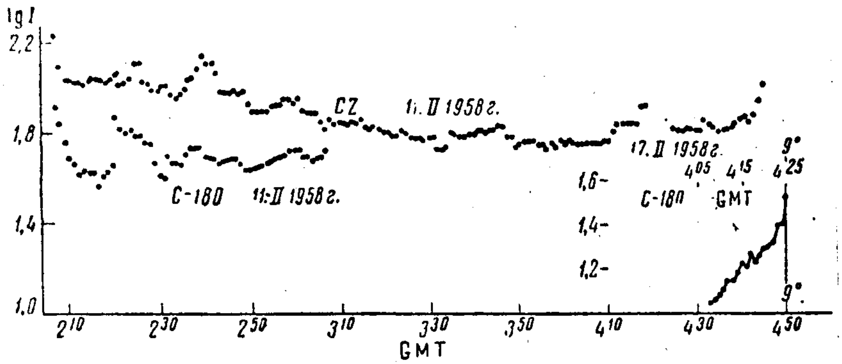

Fig. 1

Because of an exceptionally high total brightness of the whole sky, spectra obtained with 10 to 12-minute exposures by the C-180-S cameras, had a very high background level, making the line photometry extremely difficult.

Comparison of separate development stages of the aurora with geomagnetic field variations shows that the aurora was attended by a strong magnetic disturbance. However, while the 11 Feb.1958 aurora has no equal for the whole 1957 — 1961 period, geomagnetic disturbances of such character are rather often observed in Murmansk (about once to twice a month). Although the basic phase of the geomagnetic disturbance commenced suddenly at 01 25 hours GMT on 11 Feb. 1958, the aurora developed gradually.

Having appeared in the North at 23 30 hours, it had filled the whole sky by 01 20 hours. At 02 08 hours, bright-green lines were observed to the North, while red-green glow was noted near the zenith. By 02 14 hours a corona made of red and green rays had formed, and radiant bands appeared in various parts of the sky. At 02 23 hours the same corona still was there, while red glow extended from west to east forming a broad band. To the south — a red glow, and green rays covering the whole sky. The visual brightness of the whole aurora reached the 4 mark. A bright red band appeared at the zenith at 03 12 hours, after a temporary decrease in intensity having begun at 02 45 hours, reaching mark 2 at 03 00 hours. Then a strong red light diffusion was noted, which continued till sunrise, covering the whole of the sky.

The results of camera C-180 shot photometry have shown that the luminescence intensity during observations varied insignificantly, while a sharp drop of general visual brightness from mark 4 in night-time to mark 2 by morining could be noted de visu. Such inconsistency is easily explained by the fact that red glow predominated toward morning, to which the eye sensitivity is substantially weaker.

As was already noted, 37 spectra were obtained with the aid of the C-180-S spectral camera of that unusually strong glow.

Presented are in Fig. 2 a– в specimens of spectra related to three different stages of aurora development. Even a simple comparison of spectra attests to the different character of the aurora observed at those stages. If the usual spectrum was obtained in the initial period (00 09 hours), which is characteristic of a standard aurora, the second (01 45 hours) and the third (04 09 hours) were substantially different. Particularly strong λ 6300, 5577 Å lines, 1 NGN_2^+ bands, and also NII λ 5000 Å, H_β λ 4861 Å, [N I] λ 5200 Å emissions, may be noted in Fig. 2 б (see next page). Finally, a peculiarity of Fig. 2 в is the predomination of the line λ 6300 Å over λ 5577 Å, the disappearance of λ 4861 and 5000 Å emissions, the enhancement of the line λ 5200 Å and the development of the oscillating-rotating structure of the bands 1 N GN_2^+.

Presented are in Fig. 3 the results of photometry of polar aurora basic emissions according to the 37 spectra. In view of the fact that the intensity distribution along the sky is practically identical for all emissions, except λ 4861, 5000 and 5200 Å, the measurement was conducted only at the zenith. Plotted is in ordinate axis the intensity logarithm, while GMT is in abscissa.

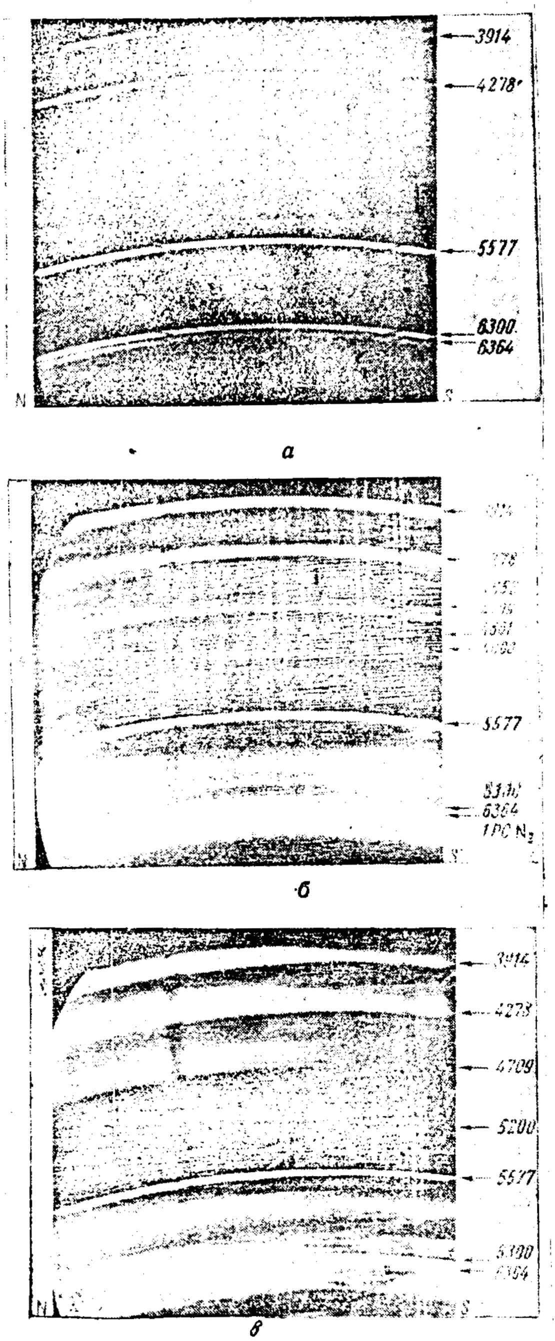

Fig. 2

The same results are plotted in Fig. 4, account being taken of the background. Since the background intensity in spectra is of the same order than that of intensity of the lines themselves, no significant value should be imparted to separate results of measurements. Both graphs give only a representation of the general character of development of separate aurora emissions, and on the redistribution of glow power in the spectrum as the aurora develops. Presented are in Fig. 5 the results of photometry of basic glow lines by spectra with 2-minute exposure. The background value here does not exceed 10 percent of the intensity of measured lines, and that is why the photometry precision is relatively high.

By examining these graphs, one may reveal certain essential peculiarities of the initial phase of 11 Feb.1958 aurora dynamics.

Being enhanced at the outset of the aurora, the green line $\lambda\, 5577\ \text{Å}$ weakens significantly toward the end of the observation, while the red oxygen lines gradually increased their intensity.

The hydrogen emission H_β appeared at 01 30 hours, reaching its maximum near 02 00 hours, when the intensity of lines λ 5577 Å and λ 6300 Å were equal, and afterward its intensity be - gan to drop gradually. (H_α was noted during that night from time to time already in evening hours). The character of the spatial distribution of H_β during the time of ob- servations is indicated in Fig. 6. Having appeared at once in the whole sky H_β progressively shifted toward the North in the morning, when the λ 6300 Å intensity exceeded significantly that of λ 5577 Å.

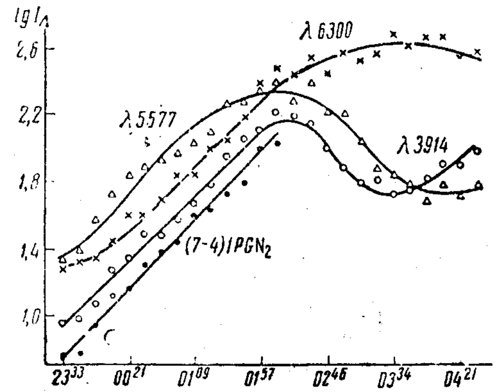

Fig. 3

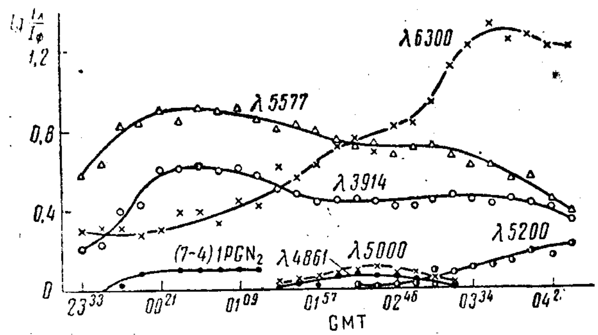

Fig. 4

Similarly the beha- vior of the allowed nitrogen emission is λ 5000 Å, while the forbidden line [NI] λ 5200 Å has another variation character, simi- lar to that of red oxygen lines. As to the bands of the first positive nitro- gen system, nothing more specific can be said besides the fact that their in- tensity increases at the outset of the aurora, on account of the presence in the red region of the spectrum of an exceptionally strong background. The intensity measurement of line's λ3914 Å edge in various spectra attests to the fact that its intensity follows the va- riation of the green line. The peculiarities of band 1 N G N_2^+ vari-

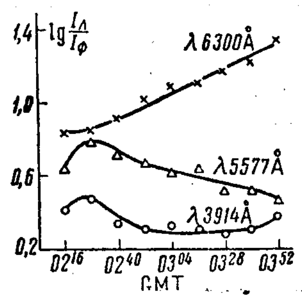

Fig. 5

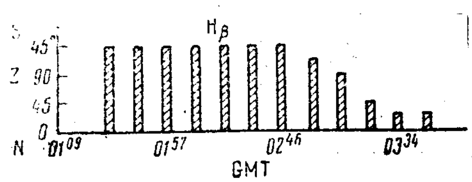

Fig. 6

variations consist in the appearance of a high oscillating-rotating excitation at the end of the night, which developed as the intensity of red oxygen lines increased. This refers particularly to the time, when the line λ 6300 Å intensity increased sharply by comparison with the line λ 5577 Å. Because of the fact that the resolving capability of the C-180-S camera is not great, one may only speak of the aggregate effect of the oscillating-rotating band 1 NGN_2^+ enhancement.

An anomalous development of the oscillating-rotating structure of the line λ 5278 Å (0 – 1) is clearly visible in Fig. 7, which

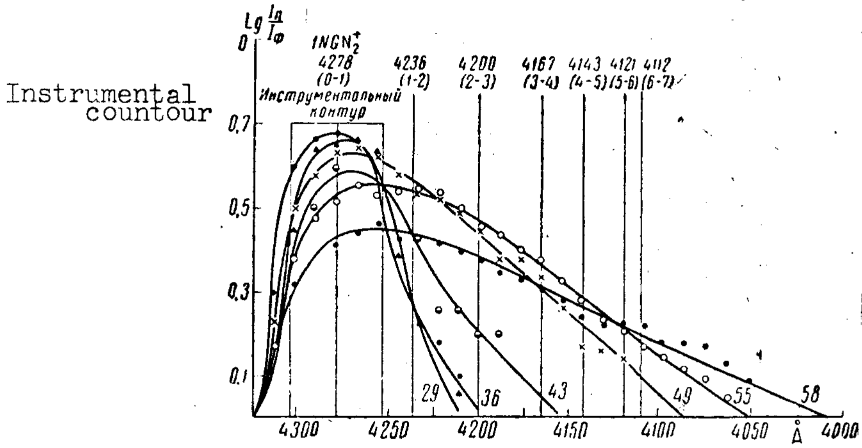

Fig. 7

attests about the excitation temperature increase to several thousand degrees. Since the phenomenon took place in morning hours, there is ground to believe, that the solar wave emission contributes substantially to the observed effect.

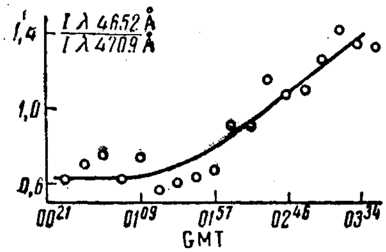

Fig. 8

The variation of intensity correlation between the lines 1 N GN_2^+ 4709 Å (0 – 2) and λ 4652 Å (1 – 3) is evidence of the gradual increase of the oscillating temperature.

Presented is in Fig. 8 the intensity variation of the line λ 4652 Å relative to 4709, as the aurora develops. In the initial stage this ratio was small (0.60), which corresponds to the excitation temperature of normal aurora (hundreds of degrees), while toward morning it notably exceeded the unity, which in all probability may be linked with the significant increase of the oscillation temperature (thousands of degrees).

The examined peculiarities of the abnormally strong polar aurora of 11 February 1958, observed in a great altitude range, attests to the fact that it was apparently caused by a stream of corpuscules of exceptionally high density, whose mean energy, however, was usual.

**** THE END ****

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Translated by ANDRE L. BRICHANT
for the
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14 July 1962

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